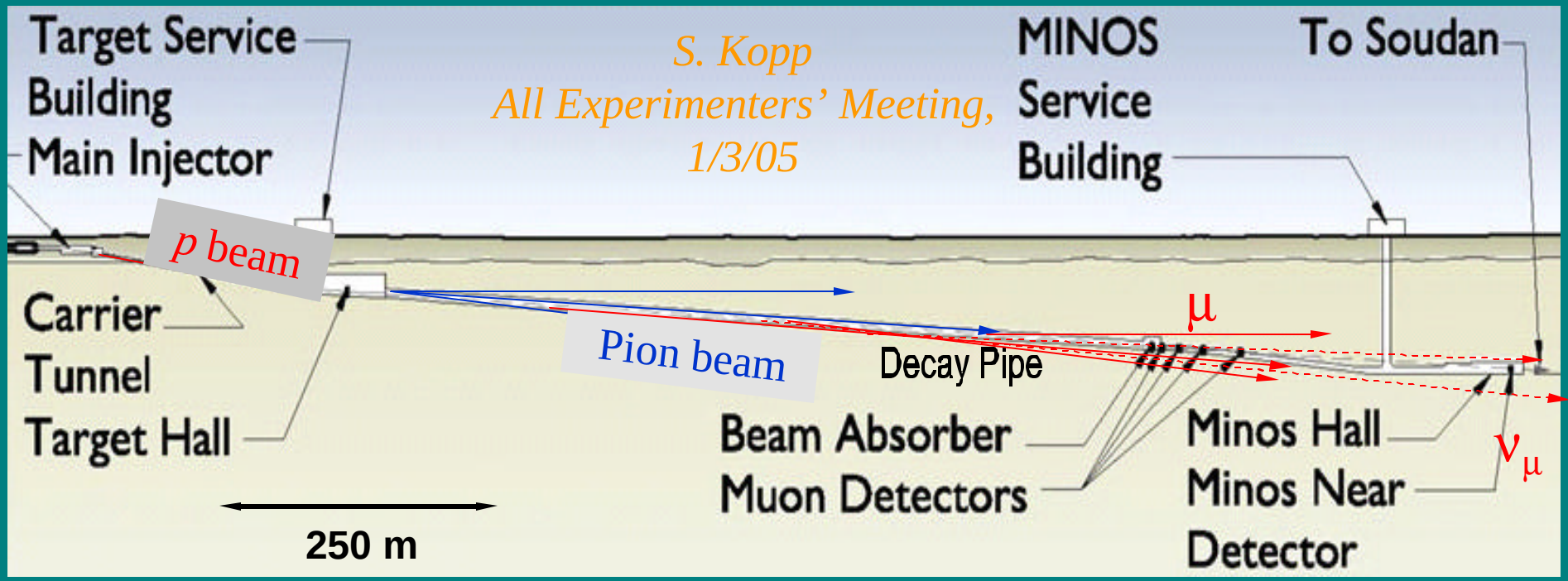
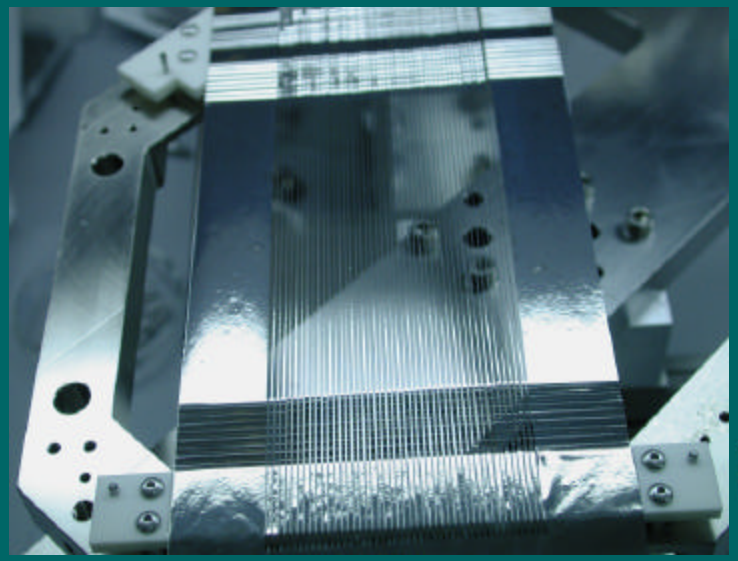
Instrumenting *the* NuMI Beam



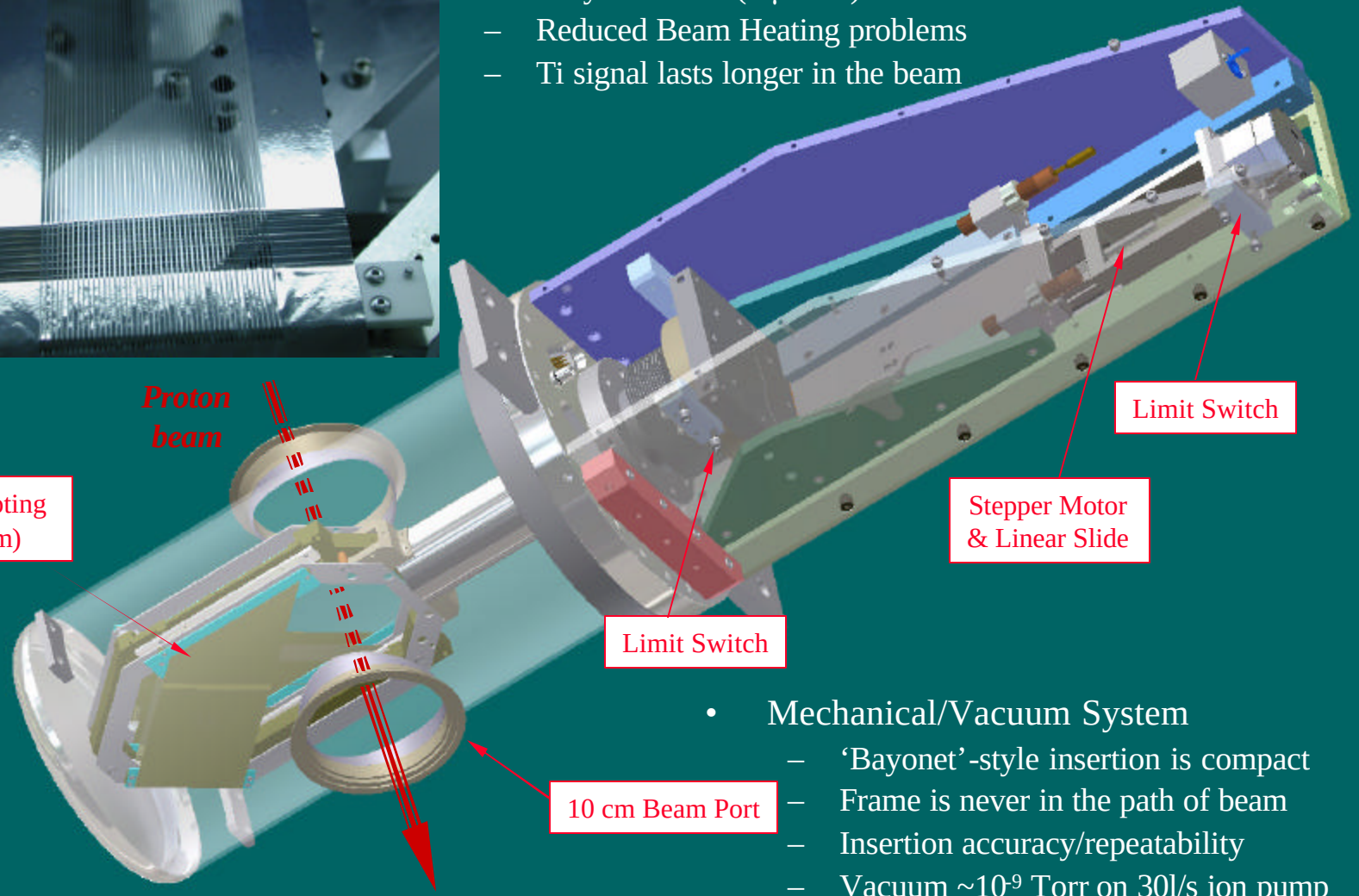
	Goal	Worry
Primary	Beam transport, targeting	Intense beam, instrument damage, beam loss
Secondary	Target & horn integrity	Radiation damage, high particle fluxes
Tertiary (μ)	ν flux and direction	High particle fluxes, 1% precision

Segmented Foil SEM's



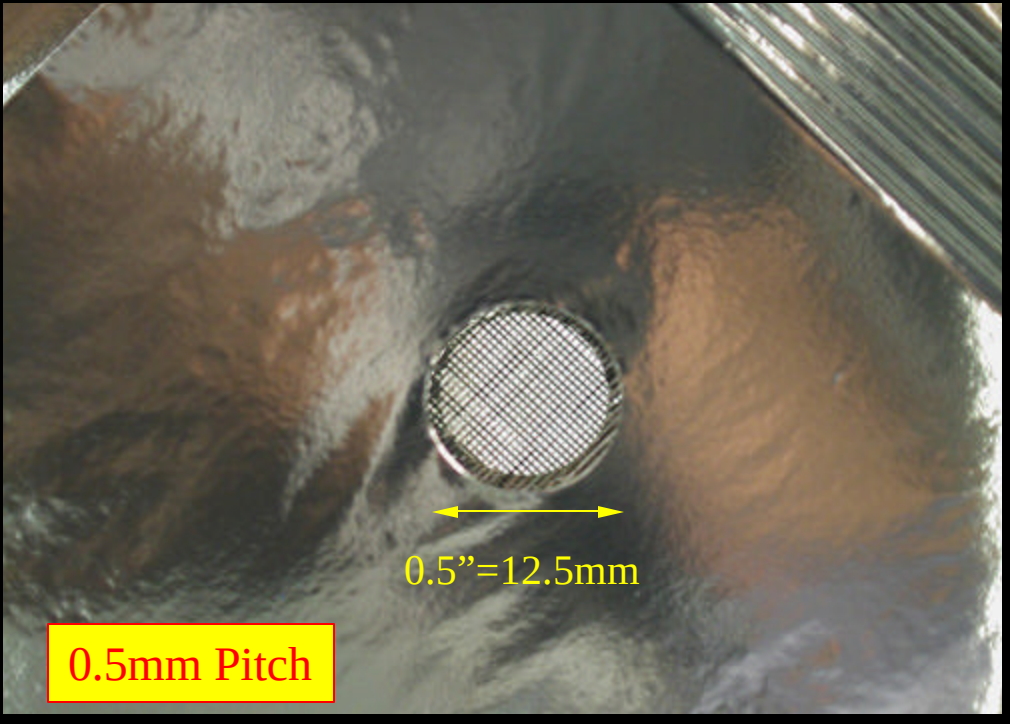
Foil Secondary Emission Monitors

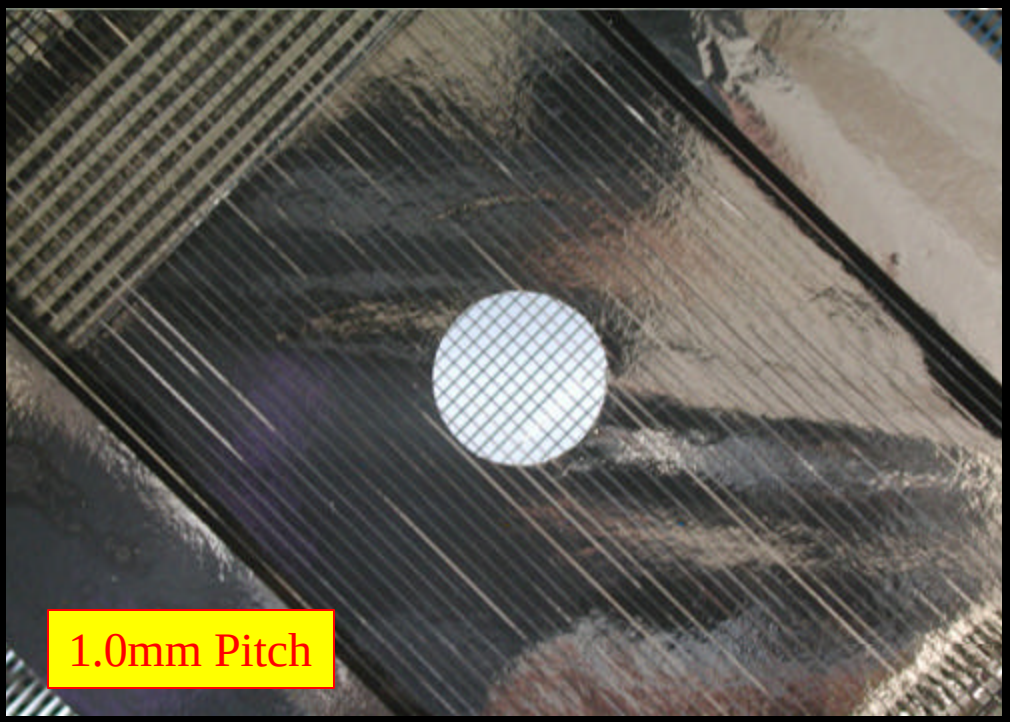
- Beam profile + halo measurement
- Very low mass (5 μm Ti)
- Reduced Beam Heating problems
- Ti signal lasts longer in the beam

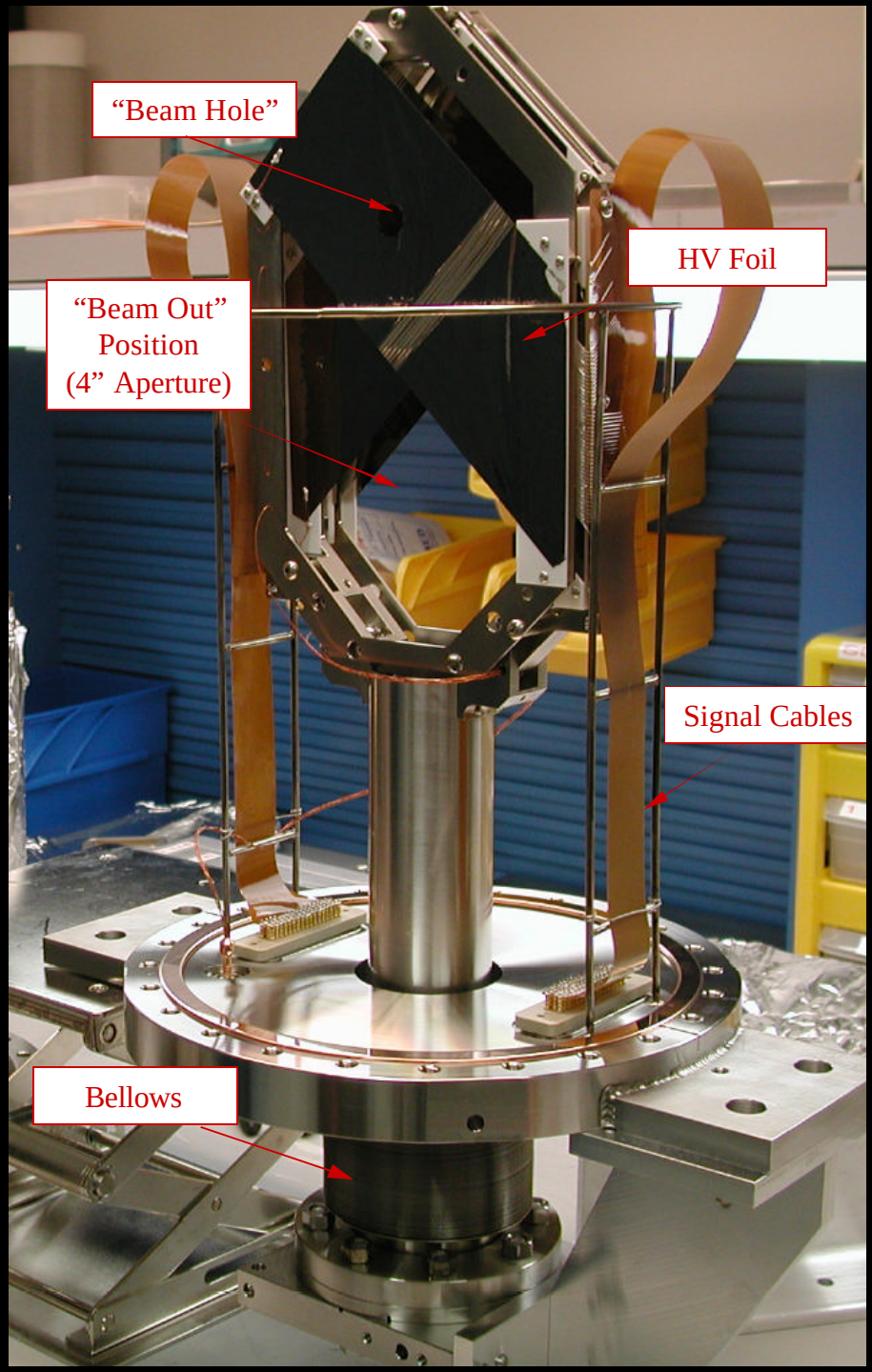


- Mechanical/Vacuum System
  - 'Bayonet'-style insertion is compact
  - Frame is never in the path of beam
  - Insertion accuracy/repeatability
  - Vacuum ~10^{-9} Torr on 30l/s ion pump

www.hep.utexas.edu/~kopp/minos/sem/


0.5”=12.5mm
0.5mm Pitch


1.0mm Pitch


“Beam Hole”
HV Foil
“Beam Out” Position (4” Aperture)
Signal Cables
Bellows

New NuMI BPM's

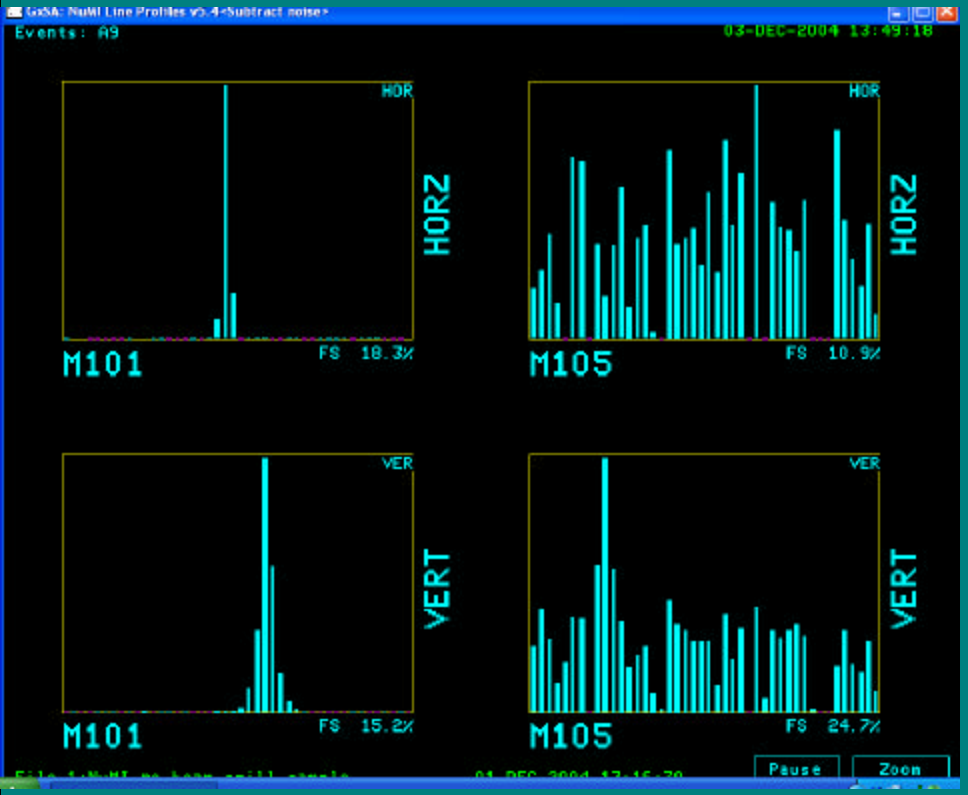
- FNAL Instrumentation Department
  - Peter Prieto
  - Duane Voy
  - Charlie Briegel
  - Jim Fitzgerald
  - Bob Webber
  - Numerous others…

- Some of the newer features:
  - Software algorithm to search ~400μsec span to find the beam (eliminated need for timing)
  - Batch-by-batch information (up to 6 Booster batches per NuMI spill)
  - *Ab initio* fiducialization and calibration of beam center
  - Linear over 15-20mm span (*cf* 10mm for MI BPM's)

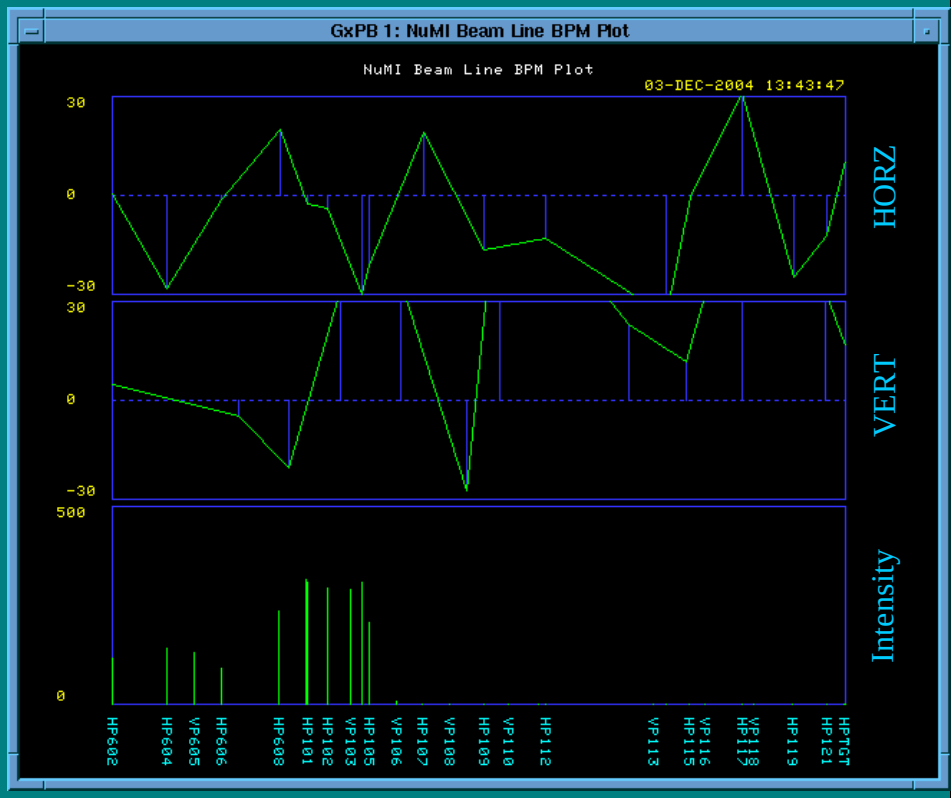

MI Q105
HSEM
Toroid101
BPM
MI Q101
Installed in NuMI line
Final Focus to
NuMI Target Hall
Shielding Wall to
Target Hall
ToroidTGT
Final BPM's+ SEM's

First Pulse out of Main Injector
Dec. 3, 2004

Foil SEM's

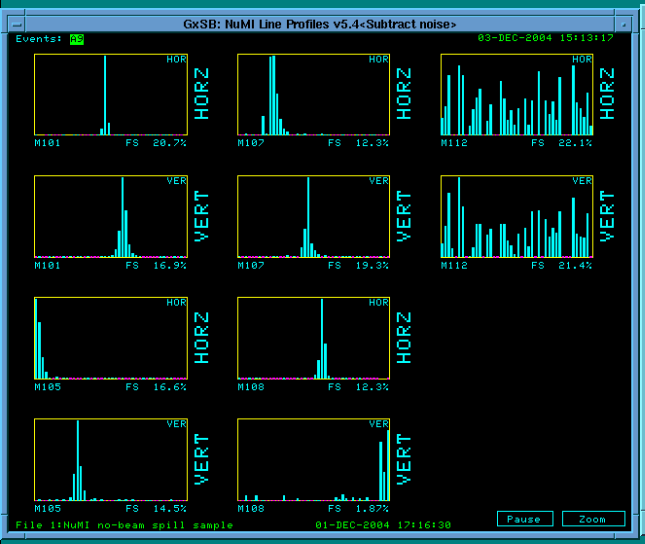


BPM's

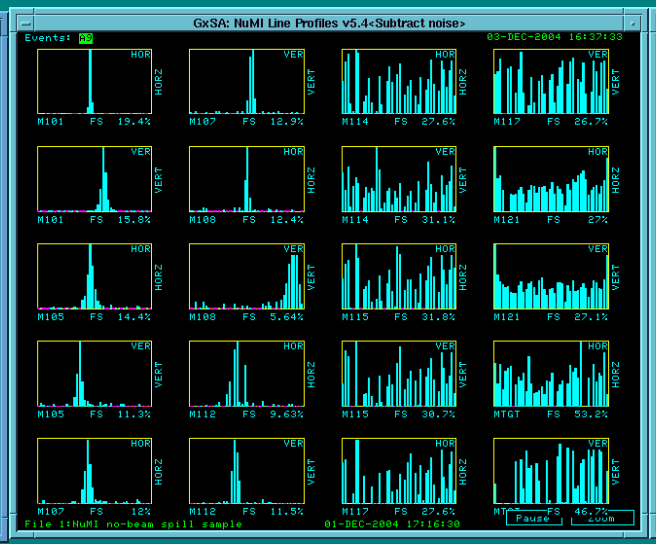


Beam Marches Down the Line…

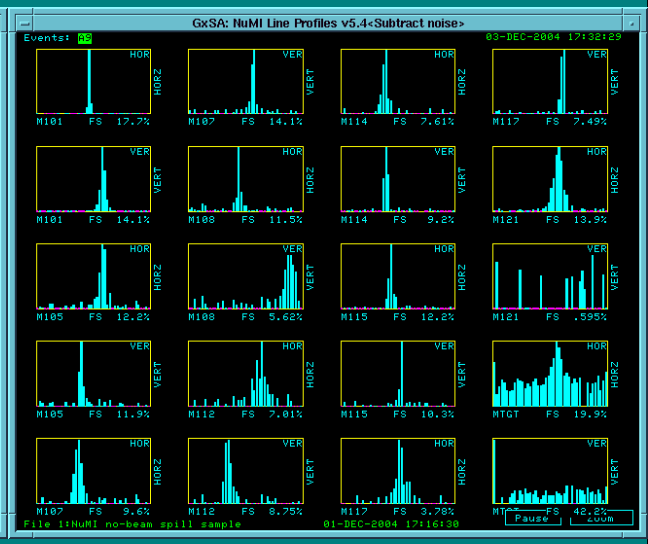
Pulse 4



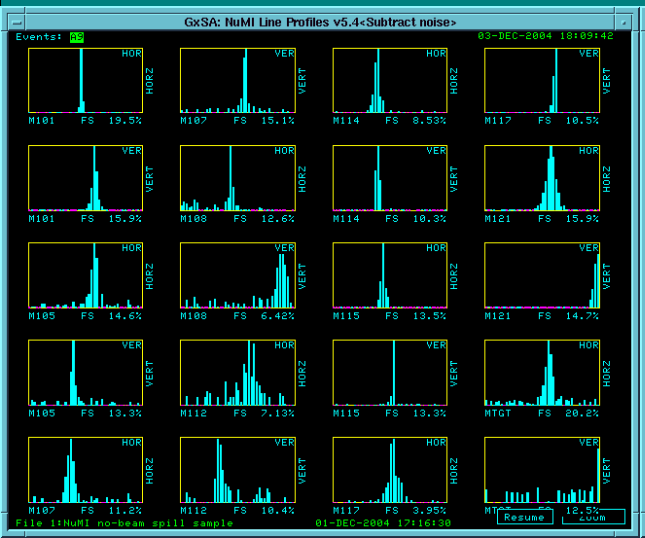
Pulse 6



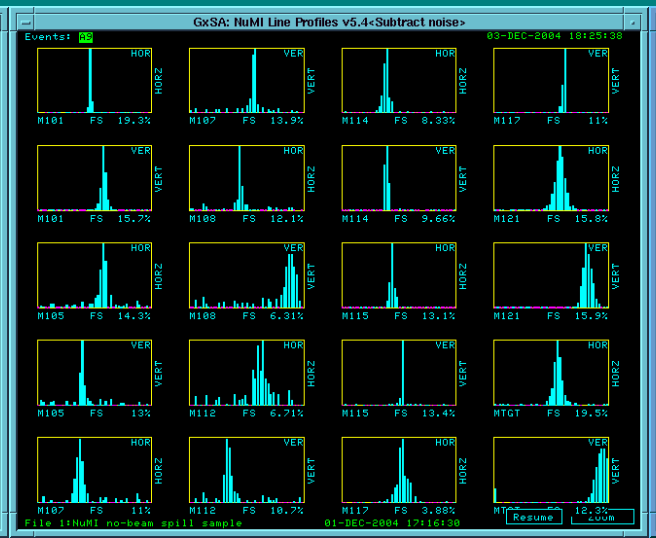
Pulse 7



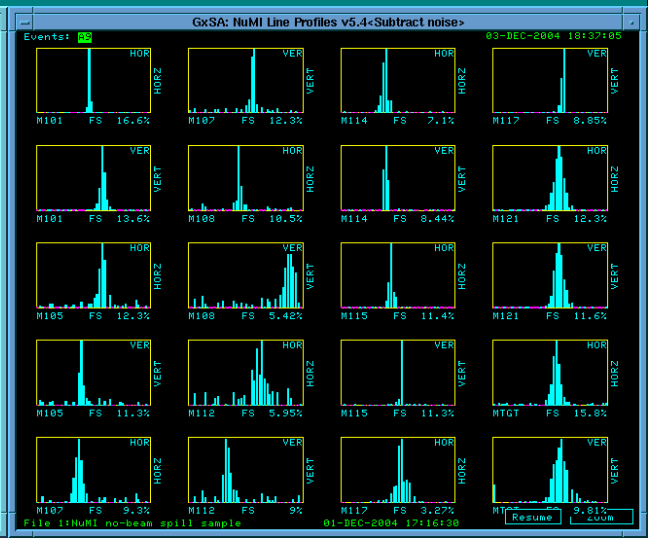
Pulse 8



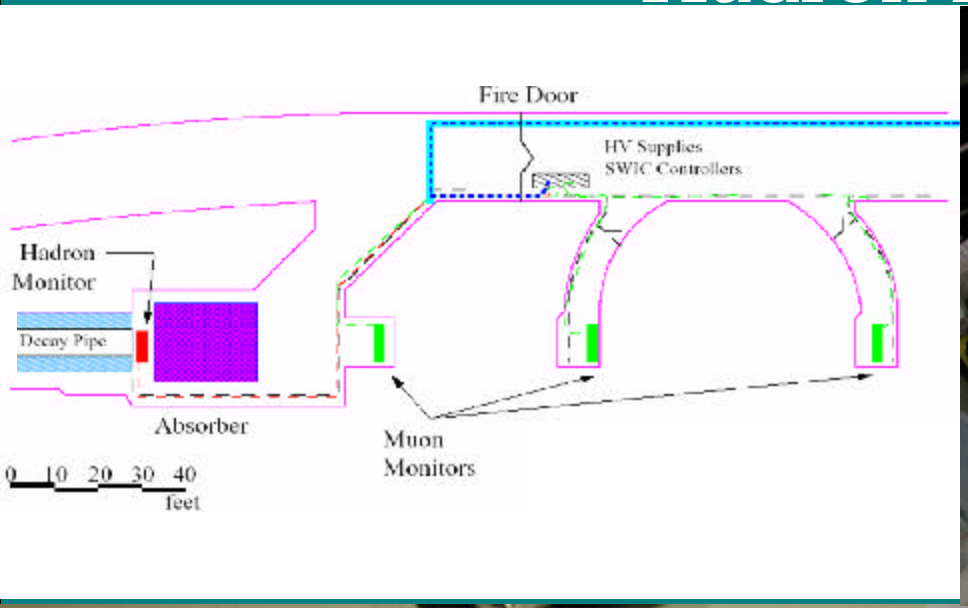
Pulse 9

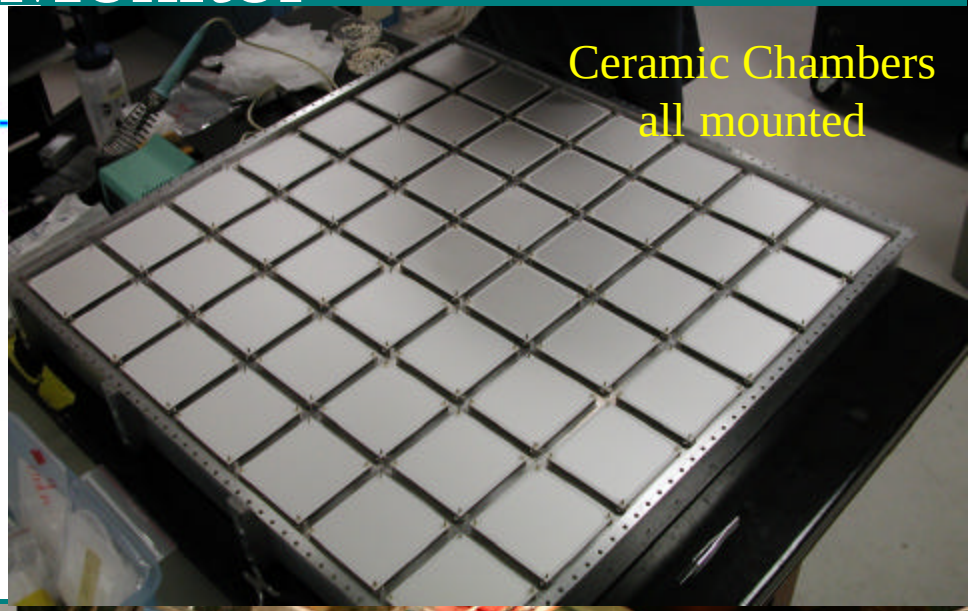


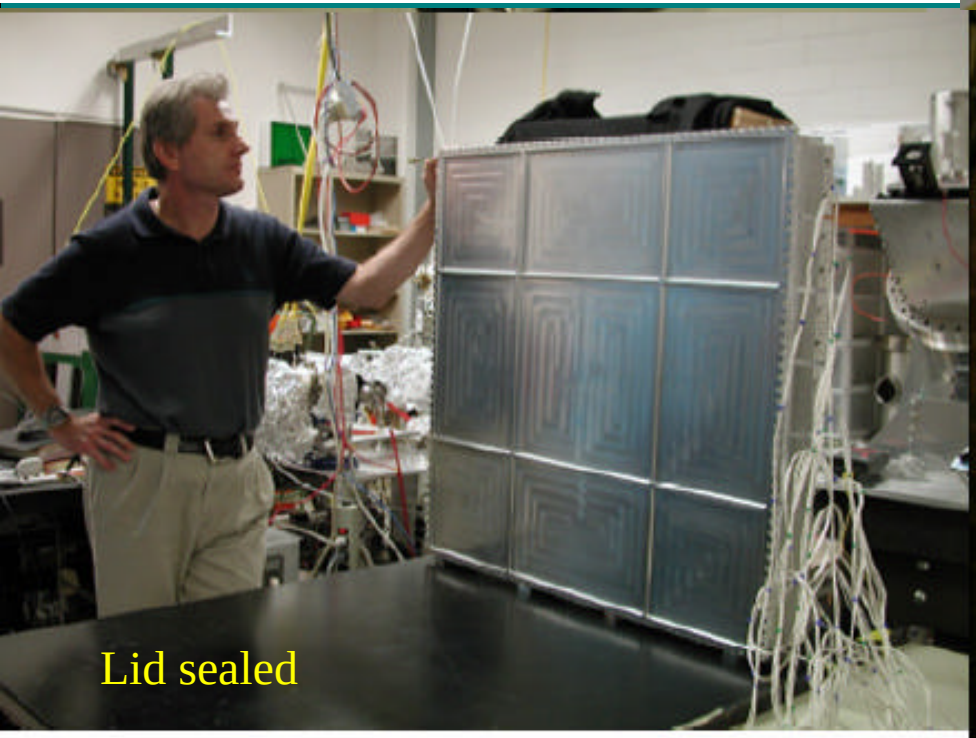
Pulse 10



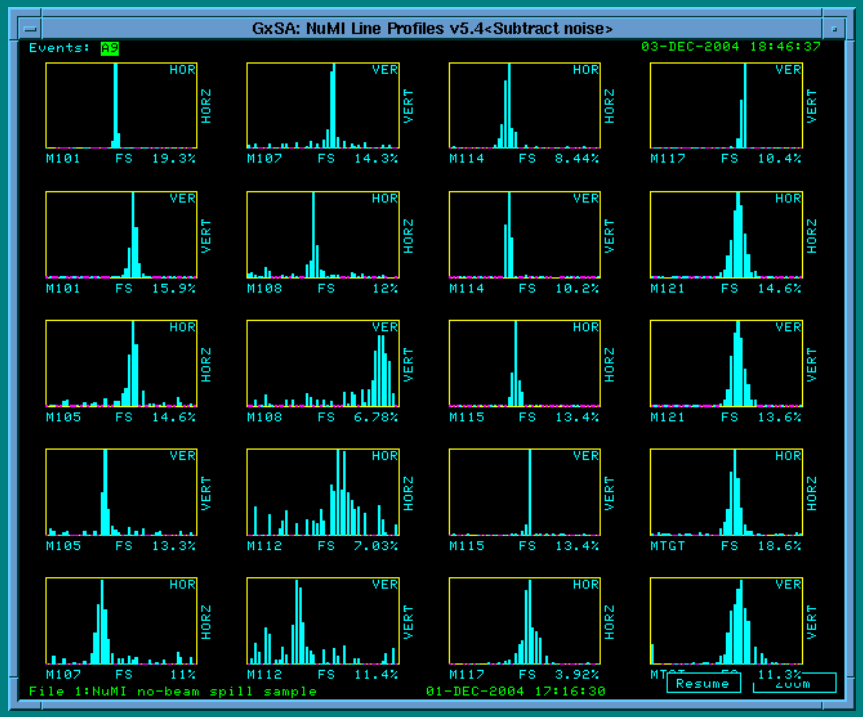
Hadron Monitor

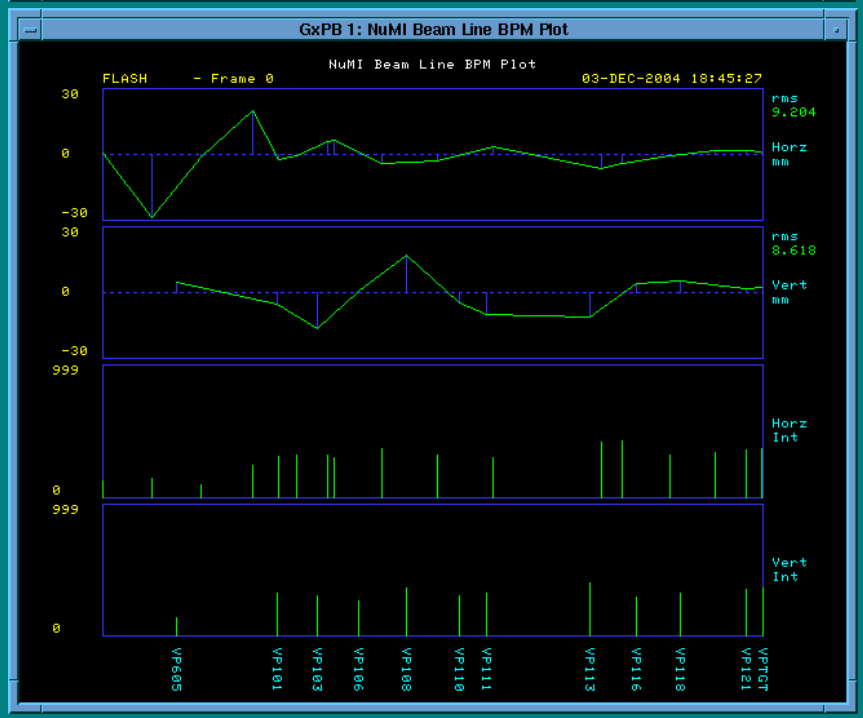


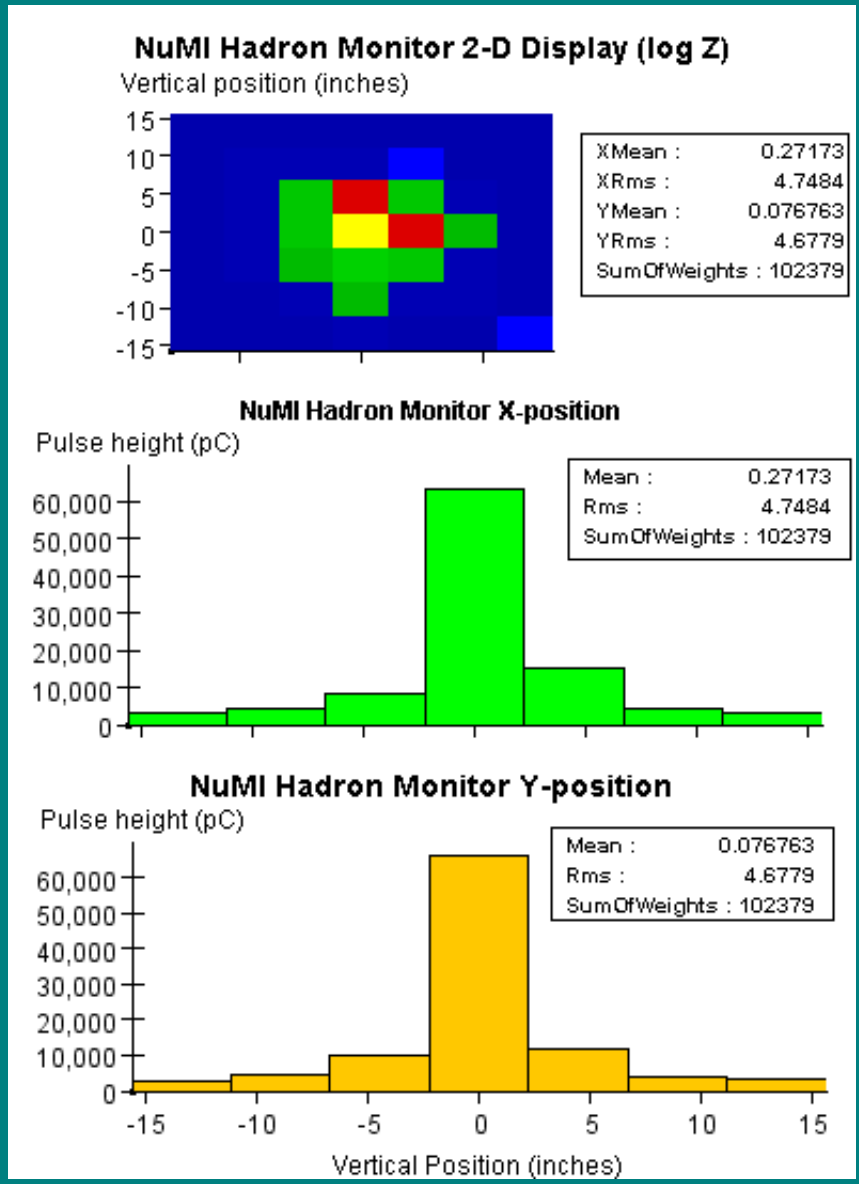




Hitting the Hadron Monitor





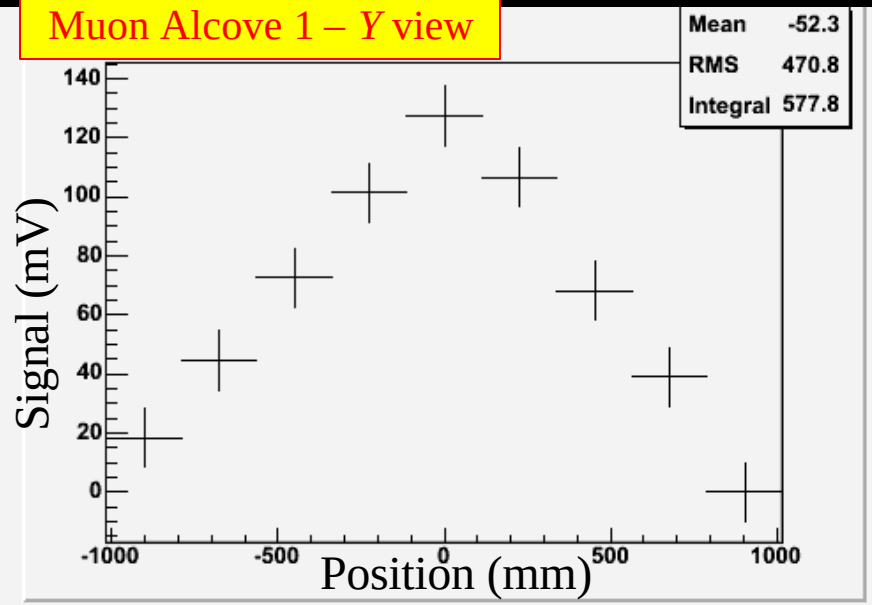


µMonitor Stations

(for Dec. run expect mostly background neutrons + a m's from absorber)

- 2m x 2m He-filled ion chamber array.
- 3 arrays at different rock depths
- 9 vessels, each has 9 chambers.
- Precise 1% relative calibration

Muon Alcove 1 – *Y* view



NB: 10mV = 1pC

Summary

- Instrumentation Summary from Dec. 3-4
  - All the instrumentation was available on the 1st pulse
  - Spills ~2-3E11 ppp (1/100th of final NuMI)
  - All 24 BPM polarities all correct
  - One foil SEM polarity swapped (out of 20)
  - Hadron Monitor bell rang when hit
  - Alignment and fiducializing of instrumentation bang on.

- Next run of the NuMI line Jan 15-16
  - Target and horns in the beam
  - Spills ~2-3E12 ppp
  - Muon monitors to confirm ν flux *via* muons.
  - Total 4E14 POT to see neutrinos in near det